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U.S. PATENT APPLICATION

Inventor(s): **Håkan NISKA**
Bo KVARNSTRÖM
Jan OOM

Invention: **OPEN 'PLUG & PLAY' O&M ARCHITECTURE FOR A RADIO BASE STATION**

NIXON & VANDERHYE P.C.
ATTORNEYS AT LAW
1100 NORTH GLEBE ROAD
8TH FLOOR
ARLINGTON, VIRGINIA 22201-4714
(703) 816-4000
Telecopier (703) 816-4100

SPECIFICATION

"OPEN 'PLUG & PLAY' O&M ARCHITECTURE FOR A RADIO BASE STATION"

FIELD OF THE INVENTION

This invention relates to cellular mobile telephone systems, and more particularly to base station designs for such systems.

BACKGROUND OF THE INVENTION

Cellular mobile telephone systems operate by dividing geographic areas into cells. The network is configured so that interference between the cells is minimized. Groups of cells are serviced by assigned base stations to act as the radio interface between mobile telephones within the cells communicating with other telephones within or outside of their own cell. When a mobile telephone within a particular cell places a "call," it does so by sending a message to the Base Station assigned to its cell by identifying which telephone (or network server) it wishes to communicate with. The Base Station can communicate the message to a Mobile Network for further communication to another Base Station (to connect the caller to the desired other telephone), or can communicate the message to an appropriate Network Server (to connect the caller to some type of Network service).

Several factors can affect the size and type of the cells that the Base Stations service. A common occurrence is the dramatic

enlargement of the density of mobile telephones within a particular cell such that the capacity of a Base Station servicing the cell becomes overly taxed. In such cases, the cell can be subdivided and additional Base Stations can be added to service the smaller geographic cell areas. Today, for example, a Mobile Telephony Network may employ 3000 Base Station sites, with annual expansion of 500 new Base Station sites being realistic. Other changes can also affect the cell servicing. For example, newer and improved Base Station technologies are being developed, which may be desirable for a particular cell location. In such cases, the replacement of an existing Base Station in a cell area with the improved design may occur.

When such changes occur in the Base Stations servicing a particular cell, the Base Station must be configured to perform the tasks common to cells in general and unique to the cells that the Base Station is servicing. This configuration process usually employs the identification of the systems used by the new Base Station and the customization of those systems to the particular application. One such system is the Operation and Support System, which as used in this disclosure, means an application for certain operation and maintenance functions that can exist both on an element level (to manage a single network element such as a Base Station) and on a Network level (to manage a whole telephony network). The term Element Management refers to the operation and management of a single network element and the term Network Management refers to the operation and management of an entire

network. Typical Element Management activities relevant to the present invention include (without limitation) installation, commissioning, hardware supervision, and software supervision of a single network element. Typical network management activities include (without limitation), setting up message routing information, supervising network performance, collecting accounting information, etc.

Whenever a Base Station is added into traffic service, or when hardware is added to, changed, or removed from an existing Base Station, the modification will by necessity require some type of reconfiguration in the Mobile Network that uses the existing Base Station. The cost (for e.g., introducing a new Base Station into a cell that is currently operating too close to the Base Station's capacity), is primarily in cell planning, site establishment, hardware establishment, and Mobile Network reconfiguration. The present invention addresses the last of these costs, Network reconfiguration, regardless of the impetus for the reconfiguration.

Currently, Network reconfigurations are performed manually. First, a new base station is installed. Then, Network (cell) planning occurs to determine the capacity of the installed hardware. (Note that a base station of any capacity can be installed anywhere and the network can then be configured to make the best use of it in the network). A Network Operator manually preconfigures the Mobile Network to accept and use the new Base Station or Base Station equipment. The Operator then informs the Base Station installation

team which preconfiguration details are used so the team can introduce them to the element manager at the Base Station site. Because Base Station technology evolves, the types of Base Station equipment, the types of preconfigurations, the types of hardware and software, the upgrade characteristics, etc. of the thousands of Base Stations employed in an entire Mobile Telephony Network simply cannot realistically be made uniform. We expect that different types of Base Stations and different types of Base Station equipment will be employed throughout a Mobile Telephone Network. Thus, administration (and preconfiguration) of many different kinds of Base Stations and Base Station equipment cannot be avoided. But, currently, the preconfiguration of these many different types of hardware must be performed both at the element management level and at the network management level, which introduces additional costs, and which introduces the possibility that the information loaded into these two different management levels (one by the network operator and the other by the installation team) is not consistent due, for example, to human operator input errors.

SUMMARY OF THE INVENTION

The present invention aims to reduce the cost of reconfiguring a Mobile Network whenever a Base Station is added or removed from the traffic switch. The present invention eases the manual configuration burden that occurres whenever a Base Station is added to or removed from a Mobile Network by employing a

Plug and Play routine within the Base Station. In this way, when a new Base Station is introduced to the Network, the Base Station itself states its traffic capabilities to the Mobile Network. The Mobile Network automatically processes the capabilities data into a configuration (frequencies of operation, control channels, etc.) for the Base Station.

In a further aspect of the invention, the Base Station communication of its capability to the Network is in a standard format so any Mobile Network can understand it.

DESCRIPTION OF THE FIGURES

Other advantages and objects of the present invention will be described in detail with reference to the accompanying drawings, in which:

Figure 1 is a schematic example representation of mobile stations and a base station that may be employed in accordance with the present invention;

Figure 2 is a schematic example representation of a base station, switching system, and operation system employed according to an example embodiment of the present invention;

Figure 3 is a schematic example representation of more detailed subsystems within the example embodiment of Figure 2;

Figure 4 is a schematic example representation of an example base station according to one aspect of the preset invention;

Figure 5 and 7 are example embodiments of an information model according to the present invention; and

Figure 6 is an example embodiment of a plug and play capability of the present invention.

DETAILED DESCRIPTION OF THE PRESENTLY PREFERRED EMBODIMENTS

In a Mobile Telephony system today, an operator must administer a large number of different types and configurations of Base Stations. As changes occur in mobile telephone use within a particular region, changes necessarily occur to the hardware and software servicing that telephone use. When a new Base Station is added to a system, for example, telephone operating companies must ensure that the cell planning, maintenance, and equipment expansion is accurately and expeditiously carried out. In fact, such planning must necessarily occur even when an existing Base Station is simply upgraded.

One aspect of a mobile network reconfiguration involved getting the Mobile Network acquainted with the equipment or upgrades being introduced at a particular Base Station. In the past, this was accomplished by having a human operator interface via a computer with the Mobile Network to introduce the Network to the

particular configurations that would ultimately be employed at the Base Station. Then, another human operator would interface via another computer with the Base Station and configure the Base Station in accordance with the information provided to the Mobile Network. This involved three steps: the first human preconfigured the network at the network control site, the first human verbalized the preconfiguration data to a second human at the Base Station site, and then the second human preconfigured the Base station in accordance with the data verbalized to him.

The present inventors have discovered that the process of configuring new Base Station Equipment and Upgrades can be accomplished much more easily by pre-programming the Base Station to introduce itself to the Network by informing the Network about its capabilities. The Network then considers the Base Station capabilities and re-designs the traffic parameters and characteristics in accordance with the capabilities of all of its element nodes, including those of the new Base Station. Finally, based on the re-design, the Network communicates pre-configuration data to the Base Station, which the Base Station loads and employs in its normal operation.

With the automated preconfiguration of both the Base Station and the Network, new equipment can be introduced at a Base Station site without requiring human operators to simultaneously preconfigure the Base Station and the Network.

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Figures 1 through 3 show example schematics of the Base Stations and the Mobile Network to which they communicate. Each base station 10 services a number of different mobile stations, such as cellular telephones MS1 through MSn. The mobile stations communicate with the base station 10 by sending and receiving messages for other mobile stations or to other network components.

As shown in Figure 2, the telephony network 12 includes the base station system 10 which includes a radio base station 14 in electrical communication with a base station controller 16. The base station system 10 communicates with a switching system 18 through the base station controller 16 and a mobile services switching center 22. Typically, the switching system 18 will service a number of different base station systems 10 and thus will receive messages from a number of different base station controllers 16. The switching system is physically separate and remote from the base stations 10 that it services. Also included in the telephony network 12 is an operation and support system 20 that may be physically proximate to the switching system 18 or may be a separate facility.

The switching system 18 is generally responsible for call processing and subscriber services. It keeps databases identifying in which cells the mobile stations usually reside, where they are physically located during any given call, and which subscriber functions the mobile station is authorized to use. The switching system 18 also provides access to outside networks such as ISDN

services, foreign exchanges, etc. The base station system 10 performs all of the radio-related functions for the mobile stations 24 communicating with it. The base station system 10 includes the bases station controller 16 to handle cell configuration data and channel assignments for the base station system 10. Finally, the Operation and Support System 20 handles errors on the network and configures the switching system and base station system controllers.

Figure 3 shows some relevant aspects of the base station controller 16 and the operation and support system 20 in greater detail. The base station controller 16 communicates with the operation and support system 20 via an assigned operation and maintenance system 50 within the operation and support system 20. The operation and support systems 20 includes a plurality of such operation and maintenance systems 50-52, generally (though not necessarily) on a one-to-one basis with the base station controllers that the operation and support system 20 must maintain.

Just to illustrate an example base station controller, the base station controller 16 of Figure 3 includes several hardware and software subsystems including group switching 30, channel switching 32, traffic control 34, radio operation and maintenance 36 and radio control 40. Other or different subsystems may also be employed within the base station controller, so the example of Figure 3 can be modified in accordance with the services and hardware being employed in a particular base station application.

The group switching subsystem 30 is software and hardware that is responsible for selection, connection and disconnection of signal paths. The channel switching subsystem 32 is responsible for signaling and routing of messages. The traffic control subsystem 34 is responsible for setup and supervision of calls. The radio control system 40 administers the radio network. The radio operation and maintenance subsystem 36 is responsible for that internal operation and maintenance. What is important for purposes of the present invention is not the type or division of responsibilities within the base station controller 16, but that somewhere within the controller is an internal operation controller that relies upon some type of operating system 38 for configuring the operational characteristics of the subsystems within the base station system 10.

These operational characteristics are unique to each base station and can include, among other data, hardware and software capacity information, geographical cell configuration information, base station identity codes, RF channel numbers assigned to the cells in a base station's service area, maximum output power levels per cell, neighboring cell frequencies, etc. When base stations are added to a network or are modified, when cells are reconfigured, or when frequencies of operation are reallocated, these operational characteristics change. The base station system 10 must be informed of the changes and re-configured to accommodate the changes. In addition, the operation and maintenance system 50 in the operation and support system 20 must also be informed and configured to the changes as well.

The operation and support system 20 must be aware of all operational characteristics of the base stations 10 that it services so it can properly manage the entire mobile network via the network manager 54. The network manager is responsible for configuring the entire network via the configuration manager 55. Network operation and performance are also supervised in the network operation manager 56 and the performance manager 57. As one can see from Figure 3, since the network manager 54 must operate consistently with the capabilities of the base station controllers 16 at the various base stations systems 10 (sometimes numbering in the thousands), the base station controllers 16 must be configured absolutely consistently with what is expected by the network manager 54. The base station has certain hardware and software limits on its capacity and capabilities, while the network manager 54 has certain demands for the base station to process the mobile station 24 messages being sent in the cells serviced by the base station. The operation and support system 20, the base station controller 16 and the base station must exchange information to achieve an agreement on how to use the capabilities in a way that is optimal for the whole network.

With the present invention, when the base station is taken into operation, is modified, or is serviced, it informs the network manager 54 (via communication between the base station controller 16 and the operation and management system 50) what capabilities it has. This capability information can be entered manually by an operator at the base station site, or more preferably is automatically

produced by an internal base station process. In order for the base station to transfer this capability information, there must be a common understanding between the base station and the network. According to an example embodiment of the present invention, this common understanding is provided by an abstract resource information model (reflecting the base station's capabilities) which is delivered to the mobile network and specifically to the ~~mobile~~ network.

Having received the information model, the mobile network can understand the basic capabilities of the base station and can then use this common model language to configure the base station, and if necessary, adjacent parts of the network. In this way, the base station automatically gives the network manager 54 the capability information that it needs for the configuration manager 55 to configure the network to accommodate the new (or modified) base station and can send the frequencies of operation, control channels, etc. to the base stations for their use.

Figure 4 shows an example base station management architecture to employ the information model according to the present invention. First, the implementation specific parts of the base station are isolated into an infrastructure management layer. This infrastructure management layer is specific for the base station implementation and version, and requires its own element management operating system. The infrastructure management layer can be common to several different applications residing in the

network element, such as, for example, the transport network function.

The base station then divides out a base station abstract resource management layer which includes the abstract resource information model that will be employed in examining the base station capabilities by the mobile network and in receiving the base station configuration from the mobile network. The abstract information resource model is independent of the base station hardware and software implementation. This layer thus provides an information model that can represent any base station irrespective of its vendor or version.

An example abstract resource information model is shown in Figure 5. This is an example only and corresponds to a CDMA base station. This example is only for the purpose of illustrating a potential application of the present invention. The present invention is equally employable in many other, different base station applications. In Figure 5, the base station site represents the physical base station site in terms of the base station functions relevant to the control of the mobile network. The base station site typically includes attributes like Site ID and geographical position. The base station site also includes information regarding the radio resources contained in the site.

The radio connection units in Figure 5 are configurable to implement the different types of airborne channels. The radio connection units serve as transport access points for the mobile

network. Typical attributes for the radio connection units are channel type, link address, and channel-specific attributes per channel type.

The carrier units in Figure 5 represent the equipment in the "Radio Near part." Typical attributes for these units are frequency assignment, maximum radiated power, etc.

A more detailed example of the Figure 5 embodiment is shown in Figure 7, in which the base station site has the capacity of simultaneously carrying twelve radio connections. Each of two groups of six radio connections can then access three dedicated carrier units (which is useful in a CDMA softer handoff case where a mobile connection can consist of more than one "legs" in the air). This example model shows several capacity limitations. For example, the six first connections can only access the air interface using the CDMA frequencies set up in the upper three carrier units. The same limitation exists for the lower six connections. This capacity information is communicated to the mobile network via the Figure 7 model.

The model of Figure 7 will show both combination capabilities for the objects and the capabilities for each of the objects. Typical capabilities attributes are described above and include, for example, allowed frequency spectrum, maximum irradiated power per carrier unit, etc.

The combination of objects in Figure 5 provide an version- and vendor-independent model of identifying capacity and configuration information for a base station. To achieve the next aspect of the present invention, in which the base station communicates its capacity information via the model to the network in a "plug and play" fashion, the example embodiment of Figure 6 can be employed. As shown in Figure 6, the information model (at the bottom of the figure) must be translated from the base station infrastructure information. A site capabilities application is employed to perform this translation. In particular, the site capabilities application recognizes the infrastructure installed at the base station and builds the abstract information model from it. Of course, the site capabilities application also detects degradation in the base station (faulty units, removed components, etc.) and upgrades in the base station (installed units) and communicates those modifications to the mobile network via the abstract model.

Using a model such as that described above together with a site capabilities application to translate the site infrastructure information into the model, the base station capabilities information can be communicated to the network manager in a "plug and play" fashion and in a vendor- and version- independent way. The site capabilities application is very vendor- (and version-) specific since it depends on the infrastructure management layer. Human administration of the physical site and human error caused by incorrect data entry between the element and network elements are thus reduced.

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While the invention has been described in connection with what is presently considered to be the most practical and preferred embodiments, it is to be understood that the invention is not to be limited to the disclosed embodiments, but on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims.